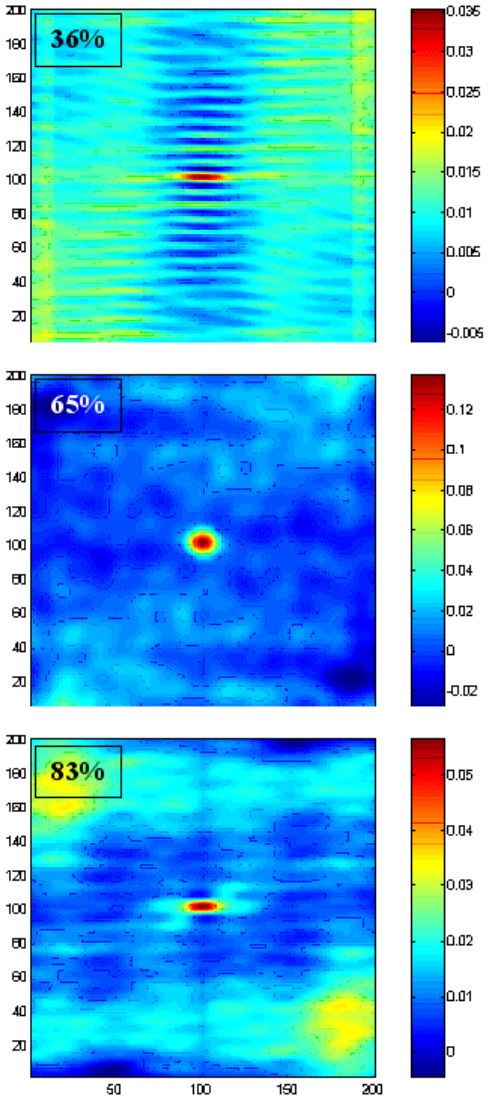
CAREER: Microscopic Study of Light Localization

Hui Cao, Northwestern University, DMR-0093949

Photons have been widely used as carriers of information in modern technology, e.g., fiber telecommunication. Ultimately we hope to use photons as information carriers in the microscopic scale as they have many advantages over electrons. By changing the metal filling fraction, we are able to switch photons from propagation mode to localization mode in the metal-dielectric nano-composites. Both propagation and localization regimes have important applications. In the propagation regime, electromagnetic energy and information can be transferred over long distance whereas the localization of electromagnetic fields in small length-scales can enhance various linear and nonlinear optical processes such as Raman or hyper-Raman scattering, frequency conversion, etc.



Measured 2D near-field intensity correlation functions in random metal-dielectric nano composites with metal filling fraction = 36%, 65%, and 83%. The incident wave is along vertical direction. λ=543nm. Both axes are in the unit of pixel (33 nm).

We measured the near-field intensity correlation functions in semicontinuous metal-dielectric films with a near-field scanning optical microscope.

With increase in metal filling fraction, we observed a transition from propagation to localization and back to propagation of optical excitations in the near-field. Both propagation and localization regimes have important applications. In the propagation regime, electromagnetic energy and information can be transferred over long distance whereas the localization of electromagnetic fields in small length-scales can enhance various linear and nonlinear optical processes such as Raman or hyper-Raman scattering, frequency conversion. This work has been submitted to publication in Physical Review Letters.

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Education:

One undergraduate (Navid Kohanpour), two graduate students (Heeso Noh, Xiang Liu), and one postdoc (Katyayani Seal) contributed to this work. Amanda Whaley is an REU student from University of Illinois. Xiang Liu received his Ph.D. from Northwestern Univ. in June 2004, and obtained a permanent position in GE research lab. Heeso Noh is a second-year graduate student at Northwestern University. Katyayani Seal is a postdoc fellow who got her Ph.D. from New Mexico State University in June 2003.

Societal Impact:

The ability to manipulate photons in the microscopic scale is very important to the development of new technology in nano-optics and nano-photonics.